NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

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IMPROVEMENT OF VISUAL DETECTION DURING "WHITEOUT"

by

S. M. Luria

Naval Medical Research and Development Command
Research Work Unit M0095-PN.001-1040

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W. C. Milroy, CAPT, MC, USN
COMMANDING OFFICER
Naval Submarine Medical Research Laboratory

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SUMMARY PAGE

PROBLEM

To determine if vision during whiteout can be improved by correcting for empty-field myopia.

FINDINGS

The ability of eight men to detect small, low-contrast targets with and without corrections for empty-field myopia was compared during a mild whiteout in the Antarctic. The distance at which the targets were detected was improved for three men, and two others reported that the clarity of the targets was improved. Three men reported no difference.

APPLICATION

The vision of many individuals caught in a whiteout may be improved by the use of glasses to correct for the magnitude of empty-field myopia which occurs. The improved vision would be of practical importance in overcoming the disabling disorientation experienced in such conditions.

ADMINISTRATIVE INFORMATION

This research was conducted as part of the Naval Medical Research and Development Command Work Unit M0095-PN.001-1040 - Protective devices for the eye in cold weather. It was submitted for review on 28 Apr 1982, approved for publication on 8 Jun 1982, and designated as NSMRL Rep. No. 984.

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ABSTRACT

The magnitude of myopia exhibited by eight men in an unstructured visual field was measured, and corrective glasses were supplied to them. Their ability to detect small, low contrast targets with and without these corrections was subsequently compared during a mild whiteout in the Antarctic. The distance at which the targets were detected was improved for three men, and two others reported that the clarity of the targets was improved. Three men reported no difference.

INTRODUCTION

One of the problems hindering military operations in the cold regions of the world is the lack of visibility caused by weather conditions. These include fogs, blowing snow, and "whiteout." The latter term, in the strict sense, refers to the situation in which the visual scene is completely and uniformly white due to multiple reflections between a snow-covered terrain and a low cloud cover (Fig. 1). The light, first of all, is reflected back and forth between the snow and the clouds until the distribution of light is uniform from every angle. In addition, the light rays are absorbed and scattered by particles in the air. These particles are of many types, but in whiteout they consist mostly of water-droplets, ice-crystals, and snow flakes. The result is that objects in the visual field suffer a loss of contrast. When the contrast of an object has been reduced to less than two percent, as a rough rule of thumb, it becomes invisible. The loss of contrast can be calculated from the distance and particle-size, and visiblity ranges can be predicted.[1]

In addition to this physical component of the whiteout phenomenon, there is also a physiological component. There are profound effects on the eye of this uniform visual stimulation throughout the visual field. First of all, under conditions in which they have less than adequate stimulation, individuals tend toward myopia, or near-sightedness. This occurs at night,[2] during high-altitude flight through a uniform sky,[3] and in turbid water.[4] Under most normal viewing conditions, accommodation is a rapid and accurate reflex which results in the optical image being precisely focused on the retina. Without adequate stimulation, however, the eye reverts to a resting state of accommodation, which may be inappropriate for the object in the field which the observer may wish to fixate. Such incorrect accommodation results in a degradation of acuity which makes perception of the object difficult. There is a systematic decline in acuity with refractive error. For simple myopia, a one diopter refractive error is associated with a Snellen acuity of about 20/50 to 20/60.[5-7] Thus, in terms of the target size which can be perceived, there is a loss of acuity of about 60%. In addition, such refractive errors constrict the limits of the visual field.[8]

Indeed, the effects of unchanging stimulation on the eye can be even more profound. Considerable research has shown that changing stimulation is essential for vision, and without it, even high contrast objects disappear in a matter of seconds.[9,10]

This loss of visibility results in a loss of orientation which, at the least, reduces performance and at the worst results in death. Descriptions of the whiteout phenomenon and its tragic consequences date from the first Arctic explorations.[11,12] Despite the advances in navigational technology, similar experiences are recounted by present-day observers in the Arctic. These include helicopter crashes due to loss of visibility on landing, and individuals lost for days within a short distance of camp.

The common solution to prevent becoming lost in whiteout is simply

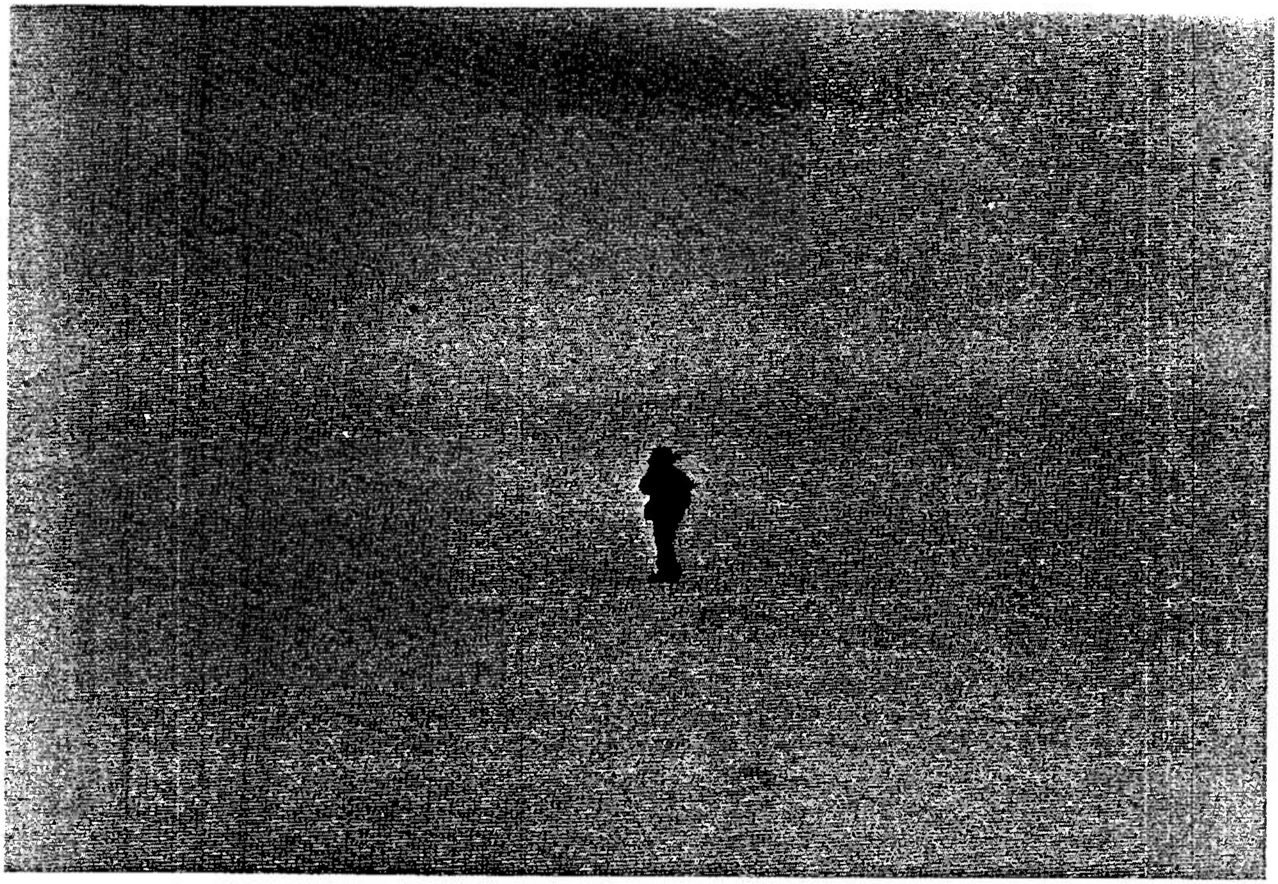

Fig. 1. Photograph of the terrain on which the experiment was carried out.

to stay put until the weather clears. This may not always be feasible, however, as when speed is essential in medical evacuations. For this reason, there has long been an interest in improving vision in such circumstances.

Attempts to deal with the problem have a long history. During World War II a special subcommittee of the Armed Forces-NRC Vision Committee was formed to work on visibility problems.[13] Harker[14] has summarized this early work. It was not successful, despite the fact that the essential reasons for the loss of visibility were known.

The stumbling block appears to have been the assumption that in an empty field the eye reverts to a state of accommodation which was thought to be at optical infinity, or at least at the same point for everyone. New techniques for measuring accommodation, however, have shown that resting accommodation is not at infinity[15] and, moreover, the magnitude of myopia varies from one individual to another.[16,17] Further, the various kinds of myopia - night myopia, instrument myopia, and empty-field myopia - are all about equal and can be predicted from the resting accommodation. These results suggest that corrections should now be possible for a given individual, since it is possible to measure the resting state of accommodation and prescribe the particular refractive correction which a given individual needs for his empty-field myopia. In fact, Post et al[18] have measured detection thresholds for small light flashes in a uniform field of view. They showed that the best thresholds were achieved when the subjects were corrected for the magnitude of myopia obtained in the dark. In all cases, this threshold was better than that obtained when the observer was corrected for his normal, photopic level of myopia.

Owens and Leibowitz[19] have shown that perception of road signs during night driving is significantly improved by lenticular corrections for night myopia, and Matthews et al[20] showed that introducing patterns into the visual field which served to reduce the amount of empty-field myopia improved the ability to detect targets.

These findings led us to undertake an attempt to improve visual performance in the field during whiteout by providing observers with individual corrections for their empty-field myopia.

METHOD

Subjects - Eight men from the Naval Support Force, Antarctica, served as volunteer subjects.

Refractive corrections * - The method used to determine the magnitude of the correction for each subject was to find the refractive correction which produced the clearest image of a small spot of light, situated at infinity, and presented in an otherwise totally dark room. As noted above, Leibowitz and Owens[17] have reported that there are no appreciable differences between night myopia and empty-field myopia. The correction for one should be appropriate for the other.

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*I am indebted to Dr. John Merritt of Perceptronics, Woodland Hills, CA, for measuring the magnitudes of night myopia of the subjects.

These corrections were incorporated in spectacle frames for each subject which could be positioned in front of their normal spectacles. The reason for not making spectacles which incorporated both their normal correction and the additional correction was that the men in the Antarctic wear special sunglasses which we could not easily duplicate. Table I gives the normal refractive correction for each man and the additional correction for his night myopia.

Targets - Two identical sets of targets, with two targets in each set, were used. Each target was 6 inches in diameter, chosen to subtend 8 min. visual arc at a distance of 200 feet, since it has been found that corrections for empty-field myopia do not significantly improve detection of targets which are much bigger than that.[21] The targets were painted one of two shades of gray so that the contrast was either .12 or .26, according to the formula

$$C = B_b - B_t/B_b$$

where the background was an aluminized movie screen.

Procedure* - On a day when there was some degree of whiteout, the two sets of targets were set in the snow at two different locations, each 450 ft from the subjects. Half the subjects observed first with their normal spectacle corrections, and half observed first with their corrections for empty-field myopia (in addition to their normal corrections).

The subjects advanced toward the targets until they could detect the lowest contrast target. The distance from the subjects to that target was recorded, as was the subject's impression of subjective clarity of the targets.

RESULTS

The distance at which the lowest contrast target was detected with and without the correction for empty-field myopia, as well as some comments by the subjects, are given in Table II. Three of the subjects were able to detect the target at longer distances with the correction. Two others were able to detect the targets at the farthest distance attempted, 450 ft, both with and without the additional correction, but they reported that the perception of the target was clearer with the additional correction. Three subjects detected the target at the starting distance in both cases and reported no difference in the clarity of the targets with and without the correction.

DISCUSSION

The difficulties encountered in attempting to ameliorate the effects of empty-field myopia have been discussed many times (cf. [19,20]). It is encouraging, therefore, that the corrections for empty-field myopia apparently had some beneficial effect on five of the eight subjects. Since the magnitude of empty-field myopia varies from one individual to another, it should not be assumed that everyone needs or would benefit from some correction. We would expect those individuals requiring a smaller

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* The experiment was carried out in the Antarctic under the direction of CDR James C. Baggett, Jr., MC, USN, the Force Medical Officer of the Naval Support Force, Antarctica. I am grateful for his cooperation and that of the men who volunteered to be subjects.

Table I. Normal refractive corrections (diopters) for each subject and additional correction for empty-field myopia

Subject	Normal correction		Additional correction for best focus in the dark	
	Left eye	Right Eye	Left eye	Right eye
BA	-2.50	-1.75	-0.25	-0.50
BO	-0.75	-0.75	-0.25	-0.25
RC	-2.50 -5.00 x 005	-2.50 -2.50 x 011	-1.00	-0.50
RG	-0.25 -0.75 x 100	-0.50 -0.25 x 80	-0.75	-0.50
PJ	-4.25 -0.75 x 010	-5.50	-0.25	-0.25
AP	-2.00 -0.50 x 100	-2.00	-0.50	-1.00
JT	-1.50 -0.25 x 90	-1.25 -0.25 x 90	-0.50	-0.50
JW	-1.25 -0.50 x 170	-1.50	-1.00	-1.50

Table II. Detection distances (ft) of lowest contrast target with and without correction for empty-field myopia and the subjects' evaluation of correction.

Subject	Without correction	With correction	Subjective impression
BA	450	450	No difference
BO	450	450	No difference
RC	350	450	
RG	450	450	Greater clarity
PJ	400	450	
AP	450	450	Greater clarity
JT	400	450	
JW	450	450	No difference

correction to benefit less from it.[21] There is no relationship, however, between the degree of improvement and the magnitude of the correction for these subjects.

Perhaps the main difficulty is that the degree of whiteout was not very great. We have previously found[22] that in the absence of a true whiteout situation, no improvement in vision can be demonstrated, presumably because there is no empty-field myopia. Although Fig. 1 shows that there was some degree of whiteout during the experiment, it is obvious from Table II that the targets could be detected at a considerable distance. This suggests very strongly that the subjects probably did not experience the total amount of empty-field myopia which they might otherwise have had, and that they may, therefore, have been overcorrected. Post et al[18] found that when subjects were overcorrected, their visual performance began to decline. This may have been the case particularly for subject JW who exhibited the most myopia when examined, but under the conditions of the experiment may have had much less myopia. It is, of course, just such errors in correction which have made it so difficult to effect improvements in vision in the field.

These results, however, are encouraging. There were no reversals in the data, and it seems reasonable to expect that those individuals who always saw the targets at the starting distance but reported greater clarity of vision with the correction, would have detected the targets at a greater distance had there been time to retest the subjects. Further tests should be made during a more severe whiteout, when the improvements in visibility with the correction would probably be more pronounced.

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